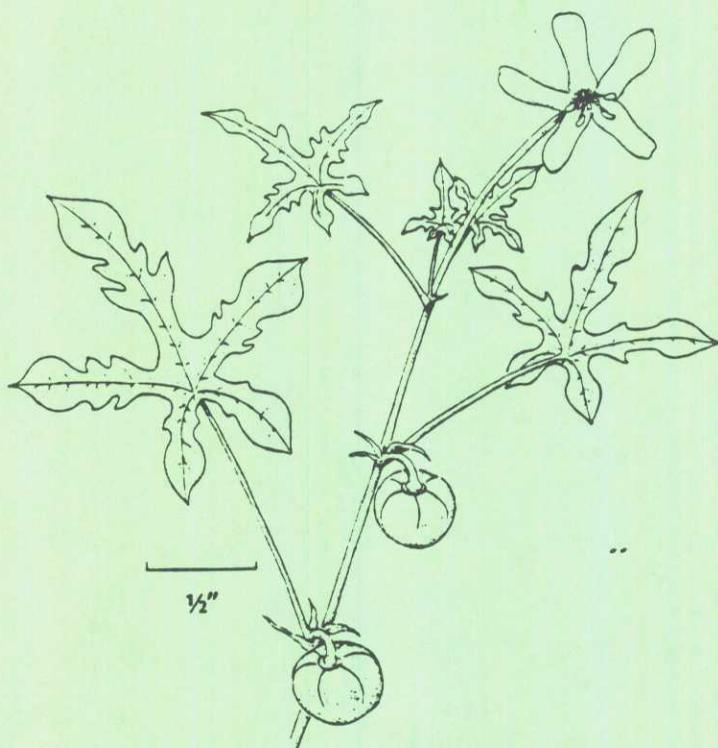


# Walker's Manioc

(*Manihot walkerae*)

## Recovery Plan



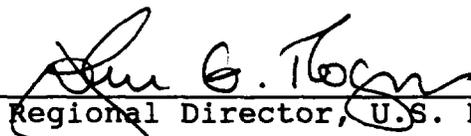
U.S. FISH AND WILDLIFE SERVICE  
REGION 2, ALBUQUERQUE, NEW MEXICO

1993

WALKER'S MANIOC  
Manihot walkerae  
RECOVERY PLAN

Prepared by:  
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For:  
Region 2  
U.S. Fish and Wildlife Service  
Albuquerque, New Mexico

Approved:   
Regional Director, U.S. Fish & Wildlife Service

Date: 12 December 1993

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Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1993. Walker's Manioc (Manihot walkerae) Recovery Plan. USDI Fish and Wildlife Service, Albuquerque, New Mexico. 57 pp.

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Fish and Wildlife Reference Service  
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## EXECUTIVE SUMMARY

Current Status: Walker's manioc (Manihot walkerae) is listed as endangered. It is known from one population in Tamaulipas, Mexico, and one population in Hidalgo County, Texas. The population in Texas consists of a single plant.

Habitat Requirements and Limiting Factors: Walker's manioc is an understory species that inhabits open brushlands in the Lower Rio Grande Valley of Texas and adjacent Mexico. Brush clearing for agriculture and pasture improvement is the most important factor contributing to habitat decline for this species. It is uncertain what effects grazing, trampling by large herbivores, and fire may have on the species.

Recovery Objective: Downlisting.

Recovery Criteria: Maintain or establish 15 self-sustaining populations of Walker's manioc in the United States. Establish management plans (public lands) or management agreements (private lands) to insure the protection of these populations.

Major Actions Needed:

1. Protect the habitat of the existing populations on private lands in the United States and Mexico.
2. Gather biological information necessary for management and develop a monitoring program for populations.
3. Search for new populations in the United States and Mexico.
4. Establish a botanical garden population.
5. Initiate a reintroduction program into suitable habitat on the Lower Rio Grande Valley National Wildlife Refuge, Texas Parks and Wildlife Department lands and other lands made available for use.

Total Estimated Cost of Recovery (\$000):

<u>Year</u>	<u>Need 1</u>	<u>Need 2</u>	<u>Need 3</u>	<u>Need 4</u>	<u>Need 5</u>	<u>Total</u>
1994	34.0	78.0	6.0	3.0	44.5	165.5
1995	21.0	63.5	6.0	3.0	44.5	138.0
1996	21.0	50.5	6.0	3.0	37.5	118.0
1997	12.0	0.0	6.0	3.0	20.0	41.0
1998	12.0	0.0	6.0	3.0	20.0	41.0
1999	5.0	0.0	0.0	0.0	3.0	8.0
2000	5.0	0.0	0.0	0.0	3.0	8.0
2001	5.0	0.0	0.0	0.0	3.0	8.0
2002	5.0	0.0	0.0	0.0	3.0	8.0
2003-2008 (each)	5.0	0.0	0.0	0.0	3.0	48.0
Total	150.0	192.0	30.0	15.0	196.5	583.5

Date of Recovery: Downlisting should be considered in 2008, if recovery criteria are met.

## ACKNOWLEDGEMENTS

The plan's author, Philip Clayton, wishes to express thanks and appreciation to the following individuals who contributed to the completion of this recovery plan: Mr. Joe Metz, Ms. Sharon Waite, Dr. Marshall Johnston, Dr. Billie Turner, Ms. Jackie Poole, Mrs. E.J. Walker, Dr. David Rogers, Dr. Subramaniam Appan, Mr. Chris Best, Ms. Gena Janssen, Ms. Angela Brooks, Mr. Steve Robertson, Ms. Pattie Leslie, Dr. Robert Lonard, Ms. Peggy Olwell, Ms. Sonja Jahrsdoerfer, and Dr. Robert Bertram. He would also like to thank his wife, Davra Clayton, for her encouragement.

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## PART I - INTRODUCTION

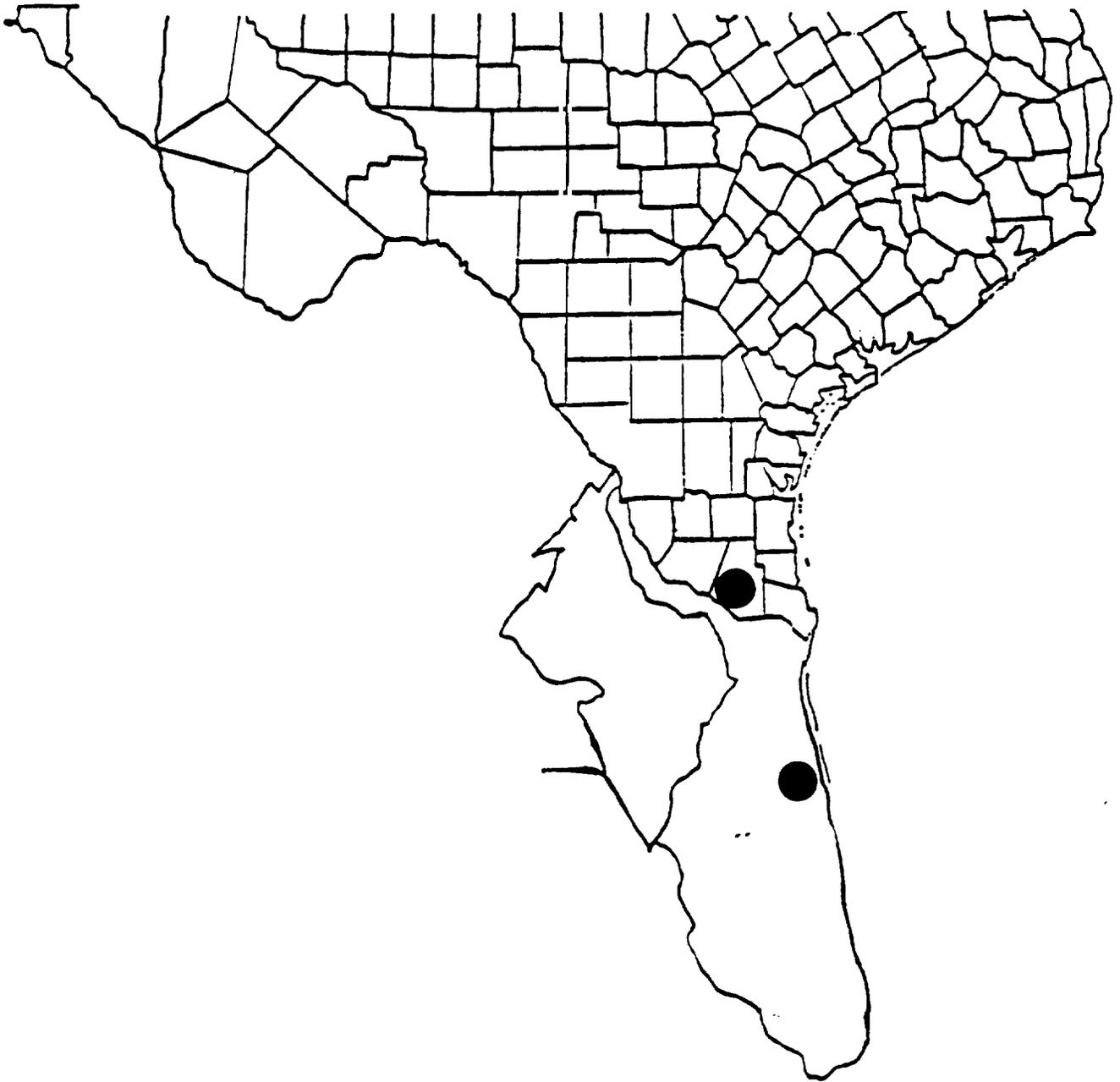
### Brief Overview

Walker's manioc (Manihot walkerae Croizat), a member of the spurge family (Euphorbiaceae), was listed as an endangered species under authority of the Endangered Species Act (ESA) of 1973, as amended on October 2, 1991 (U.S. Fish and Wildlife Service 1991). Critical habitat was not designated. In addition to being federally listed, Walkers's manioc is listed as endangered by the State of Texas. Walker's manioc has a recovery priority of 5. Recovery priorities for listed species range from 1 to 18, with 1 being the highest recovery priority. Walker's manioc was assigned a recovery priority of 5 at the time of listing because although the degree of threat was determined as high, the recovery potential for the species was considered low.

Walker's manioc is endemic to the Lower Rio Grande Valley of Texas and northeastern Tamaulipas, Mexico (Figure 1). Over 95 percent of the native brush habitat on the U.S. side of the border has been cleared for agriculture, urban development, and recreation (Jahrsdoerfer and Leslie 1988). Although numerical estimates are not available, it seems reasonable to conclude that a similar trend exists in Mexico. One population of Walker's manioc is verified from Tamaulipas, Mexico, with a possible second population needing further investigation (Francisco Gonzalez Medrano, Universidad Nacional Autonomia de Mexico, in litt. 1993). The one known U.S. population is found in Hidalgo County, Texas, and consists of a single plant.

### Taxonomy

Walker's manioc was first collected in 1853 by Arthur Schott



**Figure 1. General location of present Walker's manioc populations in Texas and Mexico.**

at Ringgold Barracks (a historic fort) near Rio Grande City, in Starr County, Texas. These specimens were sent to the herbarium of the New York Botanical Garden where John Torrey misidentified them in 1859 as Janipha loeflingii and J. loeflingii var. yuquilla. In 1866, Nathaniel Britton annotated these specimens as Manihot carthaginensis Muell. Arg., a South American species. This annotation was in error; however, it was not known until 1942 when Leon Croizat, a Venezuelan botanist, described collections from Mrs. E.J. Walker as a new species. The type locality for Walker's manioc is Hidalgo County, Texas, "Along the lower Rio Grande south of Mission." Mrs. E.J. Walker first collected plants at this location in 1940. The holotype specimen is preserved at the Herbarium of the Arnold Arboretum. In 1941, Mrs. Walker collected additional specimens "in the brush" near La Joya, Texas, and sent plants to Harris Parks at Texas Agricultural and Mechanical College for identification. Parks then sent the specimens to Victor Cory, who sent them on to Leon Croizat, who recognized and described them as a new species (Croizat 1942).

The genus Manihot was monographed by David Rogers and Subramaniam Appan in 1973. They stated, "This distinct species may be very close to extinction in the localities along the Rio Grande in Texas and adjoining Mexico due to intensive cultivation in this area." Rogers and Appan placed Walker's manioc in the section Parvibracteatae which includes North and Central American shrubs and vine-like plants with small fruits and seeds.

### Morphology

Walker's manioc is a perennial, branched, reclining to erect herb about 0.5 meters (20 inches) in height. The roots are enlarged, carrot-shaped, and about 10 centimeters (4 inches) long, with a rough, dark brown epidermis. All plant parts have a

strong cyanide odor when fresh. The stems are smooth, grayish-brown, 3.2 millimeters (0.13 inch) in diameter and die back to the root crown during the dormant season. The leaves are alternate, deeply incised, and palmately 5-lobed. Flowers are unisexual and occur in racemes with staminate flowers in the raceme opening later than pistillate ones. Pistillate flowers occur at the base of the raceme on pedicels about 1.5 centimeters (0.6 inch) long. Tepals of pistillate flowers are 1.1 centimeters (0.43 inch) long, white with light purplish external streaks, and cleft to the base. The pistil is 0.6 centimeters (0.24 inch) long with a trifid stigma. Staminate flowers are tubular, constricted in the middle; tepals are 1.2 centimeters (0.47 inch) long, light purplish streaked externally, and cleft one-fourth of the way down into 5 lobes; stamens are 6-10, filaments and anthers are cream-colored. Fruit pedicels curve downward. The fruit is a dry septicidally dehiscent globular capsule about 1.0 centimeter (0.4 inch) long. Seeds are round, 3 per capsule, 8 millimeters (0.3 inch) long and 6 millimeters (0.24 inch) wide (Correll and Johnston 1979). The seed coat is pinkish-tan with small, irregular, dark blotches. The caruncle is large and cream colored, about 2.0 millimeters (0.08 inch) long and 4.0 millimeters (0.2 inch) broad (Clayton 1990).

#### Habitat

Walker's manioc is endemic to the Tamaulipan biotic province of South Texas and northern Tamaulipas, Mexico. The habitat requirements of Walker's manioc have not yet been determined and must await additional studies on the two populations, the discovery of additional populations and management studies with cultivated specimens. The recorded habitat descriptions from collections of the species vary from native brush to grassland. A comparison of the one extant site in Texas with herbarium specimens and the population in Tamaulipas, Mexico provides some

insight into possible habitat requirements for this species. A single, mature individual of Walker's manioc was found at the only known extant site in Texas. This plant is growing in an opening within the surrounding brush approximately 2 meters from a dirt road. The general soil series at this site is McAllen fine sandy loam (Jacobs 1981). No other individuals were found during survey of potential habitat in the immediate or adjacent areas (Clayton 1990). Associated species at the Texas site include granjeno (Celtis pallida), cenizo (Leucophyllum frutescens), tasajillo (Opuntia leptocaulis), colima (Zanthoxylum fagara), mesquite (Prosopis glandulosa), coyotillo (Karwinskia humboldtiana), and anacahueta (Cordia boissieri). This area is a small fragment of brush habitat surrounded by agriculture.

The Herbarium at the University of Texas at Austin (UT-Austin) contains two voucher specimens of Walker's manioc collected at the Rancho Loreto area in Tamaulipas, Mexico, by Marshall Johnston. The first specimen (#5363B) was dated April 26, 1960, and contains the following information.

Sandy prairies overlying caliche on the Rancho Loreto. Frequent perennials to 1 foot tall, growing up through protective thorn shrubs on the overgrazed prairies. Of the many plants, only this one was beginning to flower.

The second specimen (#5572B) was dated September 16, 1960, and was a co-collection by M. Johnston and John Crutchfield. It notes the following information.

Papalote de la Mirandena, 3 miles south-southwest of headquarters, Loreto Ranch. Prairie on sandy loam shallowly overlying caliche.

Edaphic information from the extant site in Texas, the Rancho Loreto site which has recently been rediscovered (Medrano, in litt. 1993) indicates that Walker's manioc occurs in a sandy

loam soil with an underlying caliche layer at all of the known sites. Correll and Johnston (1979) report the species as occurring on caliche cuestas, which they define as being a topographic ridge with one slope being gentle and one being short and steep.

Medrano (in litt. 1993) recently reverified the ranch site noted above. This site was noted as having reduced available habitat and only 8 to 10 individuals. Medrano notes that future Mexico surveys should focus on the sandy soils underlain by limestone that occur from Rancho Loreto northeast into Texas (in litt. 1993).

It may be significant that plants at the Texas site and the Rancho Loreto site seem to occur in openings within or at the edge of dense brush or within the protection of open brush. The specimens from the Rancho Loreto site were observed growing within the protection of thornscrub in an overgrazed prairie. It is not known whether the plant had been eliminated from open areas in the prairie or whether it was associated with brush encroachment resulting from overgrazing. Medrano (in litt. 1992) did not observe any evidence of cattle grazing at this site. Rogers and Appan (1973) make a significant comment on the general distribution of the genus Manihot.

Most Manihot species are found in relatively dry regions, and only a few are typically found in rain forest regimes. Those species found in rain forest are typically found in openings in the forest...These considerations lead us to the hypothesis that most species are heliophiles, capable of growth only when there is no shading, and that many of them are "weedy" types, capable of invasion into open areas.

Johnston's comment on the label for specimen #5363B, "Of the many plants..." indicates that he may have actually observed a small population of Walker's manioc growing through the brush at

Rancho Loreto on April 26, 1960. His comment about an "overgrazed prairie" suggests that this species may tolerate some habitat degradation by livestock; however, additional field work is needed to determine what degree of disturbance is detrimental to this species.

### Population Biology

The Walker's manioc plants at the Texas site (landowner, pers. comm. 1990) and on the UT-Austin campus (Turner 1982) flower twice a year in response to seasonal rainfall. This begins in late spring and resumes in autumn. This flowering pattern is typical for plants of the Tamaulipan flora. Apparently flowers abort during the hot days of summer (landowner, pers. comm. 1990). The landowner; however, reported high flower and seed production this summer following heavy rains (pers. comm. 1993).

The reproductive biology of Walker's manioc has not been documented. Rogers and Appan (1973) recorded some general observations on the pollination biology for the genus Manihot.

In many species, the pistillate flowers are open and ready for pollination before the staminate flowers of the same inflorescence have opened. The usual pollination mechanism is provided by the insects and the sticky pollen adheres to their bodies. A wide variety of Hymenopterous insects (bees, wasps, ants, etc.) ...visit the flowers.

The one extant plant in Texas produces numerous flowers but few of them actually set seed. This may reflect inadequate cross-pollination, the lack of appropriate pollen vectors, or both. It is not known to what extent population size affects pollination success. It has not been determined whether Walker's manioc is primarily an outcrossing species or at least capable of

self pollination. However, the one extant plant may be capable of self pollination as it has produced seed for at least two years without any apparent cross pollination with other plants. None of the seed from this plant has yet been successfully germinated (Patty Leslie, pers. comm. 1992).

Specific pollinators have not yet been determined for this species but moth pollinators (sphingids, noctuids and/or saturnids) could be possible. No pollinators have been observed at the flowers. The white flowers open in clusters of three or four fragrant blossoms in late afternoon and last only one day (landowner, pers. comm 1990).

Genera within the tribe Crotonoideae of the Euphorbiaceae (including Walker's manioc) disperse their seed from explosively dehiscent capsules. Contractile integuments split the capsule open as it matures and propel the ripe seeds 1 to 2 meters into the air. The landowner of the extant site in Texas places small cloth tobacco pouches with a draw string over the developing fruits to capture the seeds as the capsules dehisce.

#### Distribution and Abundance--

Walker's manioc is known only from the Lower Rio Grande Valley of Texas (Hidalgo and Starr counties) and northern Tamaulipas, Mexico. One historical location for Walker's manioc was Ringgold Barracks, an old fort located on the eastern outskirts of Rio Grande City, Starr County, Texas. Arthur Schott first collected the species there in 1853. Walker's manioc was last observed near Rio Grande City in 1940. Previous attempts to locate plants near Rio Grande City have been unsuccessful (Turner 1982). A portion of the old Ringgold Barracks site is now occupied by a modern sewage treatment facility.

Mrs. Walker first collected Walker's manioc near Mission, Hidalgo County, Texas, in 1940, but past attempts to locate plants there have been unsuccessful (Turner 1982). Mrs. Walker also collected Walker's manioc "in the brush" near La Joya, Hidalgo County, Texas, but attempts to locate these plants have also been unsuccessful. This specimen was collected in flower during April of 1940.

A single plant of Walker's manioc was discovered southeast of La Joya by Clayton in 1990. This is currently the only extant location for Walker's manioc in South Texas.

Marshall Johnston collected voucher specimens of Walker's manioc from the Rancho Loreto area of Tamaulipas, Mexico in 1960. In 1989, these locations were surveyed by Mexican botanists but no plants were found (Mahinda Martinez, University of Texas at Austin, pers. comm. 1989).

In 1992, a previously identified site was relocated by Medrano in Tamaulipas, Mexico. The Rancho Loreto site was identified as having reduced available habitat (perhaps due to heavy or longterm cattle grazing) and only eight to ten individuals (Medrano, pers. comm. 1992). Medrano has noted another possible small population at a different Mexico location that needs further investigation (in litt. 1993).

Rogers and Appan (1973) report a collection of Walker's manioc by C.G. Pringle (#2243) near Matamoros, Mexico, on July 31, 1888. Matamoros is located south of Brownsville, Cameron County, Texas. It was not noted whether this specimen was collected in flower or fruit.

Walker's manioc has been under cultivation at the University of Texas at Austin (UT-Austin) since 1940. Benjamin Tharp

planted some of the material that was received from Mrs. Walker on the UT-Austin campus. The planted population was reported as a vigorous colony until it was vandalized in the spring of 1982 (Turner 1982). The population was then reduced to a precarious stand of only two or three plants. A severe freeze in 1990 left only one plant extant at this location. The Center for Plant Conservation now has plants from the UT-Austin stand under cultivation in pots at the San Antonio Botanical Garden. They have only one plant resulting from a seed; the other plants under cultivation are the result of vegetative propagation. The percentage of seed germination from this one success is unknown.

Mrs. Walker also sent Walker's manioc plants to Harris Parks at the Texas Agricultural and Mechanical University at College Station (TAMU). However, it is uncertain whether Parks actually planted any Walker's manioc on the TAMU campus.

#### Impacts and Threats

The major threat to Walker's manioc is the destruction and fragmentation of native brush and grassland habitat. This has been accomplished mechanically, chemically, and (less frequently) by prescribed fire. Mechanical brush eradication has been used since the early 1900's. Heavy equipment is used to pull steel chains, rolling choppers, root plows, brush mowers, and tree grubbers. Mechanical brush removal methods which create soil disturbance (i.e. root plowing) are the most detrimental to native vegetation (Jahrsdoerfer and Leslie 1988). Chemical eradication of brush has been used since the 1960's. Herbicides such as 2,4-D (2,4-dichlorophenoxy acetic acid), the now-banned 2,4,5-T (2,4,5-trichlorophenoxy acetic acid) and picloram (4-amino-3,5,6-trichloropicolinic acid) are particularly destructive because they are selective on broad-leaved plants. It is not known whether the tuberous root of Walker's manioc provides it

any protection from complete destruction from herbicides. Mike Black, Soil Conservation Service, has noted that 2,4-D and picloram are primarily used on grassland and rangeland areas (in litt. 1993). Fire has also been used as a means of controlling native brush. This method is relatively inexpensive and temporarily effective against woody vegetation. It is only temporarily effective because native vegetation often resprouts from the roots after being burned.

It has been estimated that over 95 percent of the native habitat on the U.S. side of the border in South Texas has been destroyed due to clearing for agricultural usage, urban (including industrial and infrastructure) development, and recreation (Jahrsdoerfer and Leslie 1988). Remaining native habitat exists as fragments usually surrounded by cultivated fields and commercial and residential development. These remnant native tracts are potentially vulnerable to damage from currently used agricultural chemicals as a result of drift from aerial spraying and chemical runoff following rains. Joe Ideker (in litt. 1993) also reports the burning of trash from colonias as a threat to remnant tracts of brush. Increasing development pressures pose a threat to fragments of native habitat remaining that are not suitable for agricultural usage. The introduction of exotic species, especially grasses, has displaced some native vegetation.

### Conservation Measures

Taking and Trade Prohibitions. The Endangered Species Act prohibits the malicious damage, destruction, or removal and reduction to possession of listed plants on areas of Federal jurisdiction. For all other areas, the Act prohibits removing, cutting, digging up, damaging or destroying listed plants in knowing violation of any State law or regulation, or in the

course of any violation of a State criminal trespass law. The Endangered Species Act and the Lacey Act also prohibit any person subject to the jurisdiction of the United States from selling, offering for sale, importing, exporting, or transporting in interstate or foreign commerce any listed plant species in the course of a commercial activity. Under certain circumstances, the Act provides for the issuance of permits to carry out otherwise prohibited activities involving listed species.

Walker's manioc is listed as a state endangered species under the Texas Parks and Wildlife Department Code for Wildlife and Plant Conservation, Chapter 88.004. Under this code, no person may take or possess any part or all of a protected plant species from public land if the intent is for commercial sale. In addition to these restrictions on public lands, no person may take or hire another to take, possess, transport for the purpose of commercial sale.

Section 7 Requirements. Section 7 of the Endangered Species Act requires that all Federal agencies consult with the U.S. Fish and Wildlife Service (Service) to ensure that actions authorized, funded or carried out by such agencies do not jeopardize the continued existence of any listed threatened or endangered species. It is the responsibility of the Federal action agency to determine if the proposed action may affect a listed species. Informal consultations with the Service are often undertaken by Federal action agencies to assist them with their determination of a project's potential impacts. During informal consultation, the Service may be able to assist the action agency in alternatives that eliminate a potential "may affect". If a "may affect" determination is made, the Federal agency shall initiate the formal section 7 consultation process. There have been numerous informal consultations addressing concerns associated with Walker's manioc. In addition, a formal consultation with the United States Section, International Boundary and Water

Commission, United States and Mexico, regarding the maintenance and operation of their Lower Rio Grande Flood Control Project in the Lower Rio Grande Valley considered potential impacts to Walker's manioc.

Conservation Planning and Management. The San Antonio Botanical Garden, a participating institution of the Center for Plant Conservation, presently has both clonal and seed-raised specimens from the University of Texas at Austin (UT-Austin) under cultivation. The plants at UT-Austin originated from individuals collected by Mrs. Walker near La Joya, Texas.

The Lower Rio Grande Valley National Wildlife Refuge (LRGVNR) is proposing to cultivate plants from seed collected at the extant site in Texas and from clonal material from San Antonio Botanical Garden. The cultivated plants will be used to conduct management studies to help determine where the species will grow and to later undertake a pilot reintroduction program in areas of suitable habitat on refuge lands within the historic range of the species.

The landowners of the existing U.S. site have voluntarily protected the plant and its surrounding habitat. They have been cooperative with the U.S. Fish and Wildlife Service and provided helpful comments from their observations of the plant. The landowners are conservation oriented and are concerned about restoration of this species.

Francisco Gonzalez Medrano, a Mexican botanist, has recently reverified a Mexico population and is searching for additional populations under a U.S.-Mexico cooperative agreement with U.S. Fish and Wildlife Service. He has also assigned a graduate student to assess the habitat and determine community profiles of the Mexico populations. Medrano plans to establish

refugia collections of the reverified population and any new discoveries at a botanical garden in Mexico.

Research. Commercial cassava (Manihot esculenta) is an important food staple (carbohydrate source) in Africa, Asia, and Central and South America. The International Board for Plant Genetic Resources placed a priority on the collection and ecogeographic characterization of wild relatives of cassava in 1985. Species in the section Parvibracteatae (which includes Walker's manioc) were among the first designated as a priority for conservation (Gulick, et al. 1983). In 1990, Robert Bertram (Science advisor, U.S. Agency for International Development), with the University of Maryland at that time, collaborated with Roger Beachy (a plant pathologist studying disease resistance in cassava) and Barbara Schaal (a specialist in molecular characterization) at Washington University in St. Louis, Missouri, to genetically and taxonomically characterize cassava and its wild relatives. South American species of Manihot were compared with cassava along with species in the section Parvibracteatae. James Reveal of the University of Maryland provided taxonomic and biogeographic assistance to this project. Bertram obtained plants of Walker's manioc from the San Antonio Botanical Garden for his experiment. He analyzed chloroplast and ribosomal deoxyribonucleic acid (DNA) from various species of Manihot using Restriction Fragment Length Polymorphisms (RFLPs). Bertram produced a hybrid between cassava and Walker's manioc with characteristics of both species (Robert Bertram, University of Maryland, pers. comm. 1992). He is interested in Walker's manioc for its herbaceous habit and its roots that may be less perishable than cassava and therefore useful in improving the storage qualities of this crop.

Walker's manioc may possess genes for tolerance to such diseases as cassava brown streak, cassava bacterial blight, or African cassava mosaic virus. Walker's manioc is one of the few

members of an almost entirely tropical-subtropical genus that may contain genes for cold resistance.

## PART II - RECOVERY

### Objective and Criteria

The primary objective of this recovery plan is to maintain adequate Walker's manioc populations in natural habitat to insure that the species is safe from extinction. Walker's manioc will be considered for reclassification from endangered to threatened when 15 distinct (genetically and geographically) self-sustaining populations are present in areas of natural habitat where the land management is compatible with the needs of the species. Due to the present restricted distribution of the species and the limited understanding of its life history and habitat requirements, it is impossible at this time to predict what measures will be sufficient to permit delisting the species. Tasks in this plan necessary to accomplish the downlisting objective should provide the information necessary to determine if delisting will be possible and what the delisting objectives and criteria should be. When downlisting is accomplished, this plan will be revised to establish specific criteria for delisting and a monitoring plan for the species following delisting. The criteria to meet the downlisting objective are:

1. Establish or maintain 15 distinct self-sustaining populations of Walker's manioc in the United States. The establishment or maintenance of 15 populations is a target for downlisting. Many of the research tasks in this plan will provide quantitative criteria for delisting and possibly, a revision of the downlisting target of 15 populations. Each population should consist of at least 100 reproductive individuals and have an age class structure reflecting that which exists in the natural population which shows that plants are reproducing and becoming naturally established within the population. It is possible that many mature individuals

could be needed to attract pollinators and produce viable seed.

2. Establish agreements for the protection and management of all populations on private lands and incorporate management measures into management plans for populations on public lands.
3. Develop an ongoing monitoring program to include assessment of general conditions, number of individuals, age and size class, and reproductive success (seedling recruitment and establishment).

If following downlisting either of these criteria are no longer being attained, the Walker's manioc should be returned to the status of endangered.

#### Outline of Recovery Actions

1. Protect Walker's manioc populations in the U.S. and Mexico.  
The existing populations of Walker's manioc must be protected from destruction of individual plants and habitat loss or degradation.
11. Contact landowners and land managers of all known Walker's manioc sites. All parties (including the government of Mexico) must be made aware of the species to prevent destruction of any populations or impacts to habitat.
  111. Educate landowners about the extreme rarity and significance of the Walker's manioc populations on their property. The U.S. landowners were made aware of the presence of Walker's manioc on their property when the species was listed. There has been a

population rediscovered in Mexico since the listing. The landowners of this population should be informed of the presence of the species on their property. All landowners should receive information about the extreme rarity and significance of the plants on their property. The U.S. landowners should receive an explanation of the Endangered Species Act protection for plants and an explanation of Federal and state policies concerning recovery of endangered plant species. Landowner cooperation is essential to the preservation of Walker's manioc since all known populations occur on private property.

112. Encourage the establishment of stewardship agreements. Agreements with conservation organizations such as the Nature Conservancy's Texas Land Steward Society or a Mexico counterpart can be established with landowners. These non-binding agreements help recognize landowners who voluntarily protect sensitive species or ecosystems. Some landowners may find long-term agreements with conservation organizations compatible with their land use goals. These could include more binding management agreements where the landowner is paid to implement and maintain certain management practices, conservation easements, the sale or donation of land parcels to a conservation organization. Programs through which these more binding agreements could be funded include Partners for Wildlife (U.S. Fish and Wildlife Service) and private lands programs with Texas Parks and Wildlife Department (TPWD).

12. Work with landowners to develop and implement management plans for the species. Landowner cooperation and

involvement is critical to the preservation of the species and its habitat.

121. Determine landowner short-term and long-term land use goals and the effect of those goals on Walker's

manioc. The known Walker's manioc sites are under different land uses. The U.S. population is found in an opening within brush adjacent to a dirt road. The land use around the remnant tract of native vegetation includes cultivated fields, citrus groves, and a pond area managed for waterfowl use since 1989. The habitat faces immediate threats from invasive, non-native grass species and agricultural chemicals through drift from aerial spraying or runoff following rains. The Mexico population is within a cattle ranch. Although the species is not reportedly grazed, the surrounding habitat could be degraded through overgrazing to the point at which it could no longer sustain the population. Pasture improvements through the introduction of non-native grass species, mechanical brush eradication, prescribed burning of native vegetation or chemical eradication of brush could damage or destroy this population. While it is possible that some management techniques may prove beneficial to the species, at present there are too few plants in the wild or in cultivation for management experiments to be conducted.

122. Develop and implement management plans that are beneficial to the species and acceptable to

landowners. Since the Walker's manioc populations are small with limited habitat remaining, it should be possible for landowners to avoid land uses that are detrimental to the species in those areas. Long-term, site-specific management plans for Walker's

manioc need to be developed. Each site plan should ensure that the populations become stable and genetically viable and develop sustaining, viable demographic structure. The plans should include land use prescriptions for grazing management, management of invasive non-native plant species, provisions to protect populations from agricultural chemicals, and monitoring of populations. As information becomes known about the life history, ecology, and population biology of this species, it should be incorporated into the management plans. Any revision of management plans should be coordinated among all responsible parties to take advantage of new information and different management strategies.

123. Develop a monitoring program to be implemented with voluntary landowner assistance. Seek the cooperation and assistance of landowners in monitoring the populations. Landowner cooperation is essential to the recovery and monitoring of Walker's manioc. Monitoring techniques should be the same for each site so that results will be comparable between populations. Each population should be monitored at least three times annually (preferably, during and following flowering and fruiting) and have the general condition, reproductive success, fluctuations in numbers, and response to management assessed. Any decline noted in the species' condition during monitoring should be brought to the attention of all parties coordinating the species' recovery so that an effective and timely response is possible.

13. Enforce applicable laws and regulations. Federal and state agents should exercise their full authority to protect populations on private land. The legal

responsibilities of landowners for endangered plants occurring on their lands are few. If the landowners receive Federal funds or authorization for a project on their land, the Federal action agency must ensure that those activities do not jeopardize the continued existence of the species. It is a violation of the Endangered Species Act for any person to maliciously damage or destroy an endangered plant in the course of a violation of a state criminal trespass law. Investigators must obtain permission from private landowners before doing research on private lands. Since Walker's manioc is extremely rare and not presently in commercial trade, it is expected few Federal or state trade permits will be requested for this species.

Section 7 of the Endangered Species Act requires that all Federal agencies consult with the U.S. Fish and Wildlife Service to ensure that actions authorized, funded or carried out by such agencies do not jeopardize the continued existence of any listed threatened or endangered species. It is the responsibility of the Federal action agency to determine if the proposed project may affect a listed species. Informal consultations with the U.S. Fish and Wildlife Service are often undertaken by Federal agencies to assist them with their determination of a project's potential impacts. If a "may affect" determination is made, the Federal agency shall initiate the formal section 7 consultation process.

2. Initiate studies to gather biological information needed for effective management and recovery. The lack of basic information about the habitat, growth, pollination, and reproductive biology of Walker's manioc has limited efforts to define habitat and management needs for this species. No studies have as yet been carried out to provide even the most

basic biological information. Studies done to understand the requirements of the species should concentrate on factors that relate directly to management of the species and its habitat. As information is obtained, it should be incorporated into management plans to ensure appropriate management of the species.

21. Determine habitat requirements. Very little is known about the habitat requirements of this species. This information would aid efforts to predict potential habitat and to locate additional populations and enable the Fish and Wildlife Service to determine appropriate areas for future reintroduction efforts. David Rogers, one of the authors of the monographic treatment of Manihot, notes that other members of the genus with section Parvibracteatae may share similar habitats (in litt. 1993).

211. Study soils and underlying geology. Only very general information is known about soils and geologic conditions present at the extant sites. This information needs to be documented in specific detail for each site with a complete soils analysis both near the individual plants and in the surrounding habitat. This is basic information that would better enable the Fish and Wildlife Service to determine specific habitat requirements, predict additional potential habitat for surveys, and to successfully reintroduce the species.

212. Determine community structure. The community structure of the known sites has not been characterized in detail or quantitatively. There is not data available on the Mexico population at this time. Only general edaphic information and a list of

associated species has been recorded for the Texas site. An analysis of the community structure needs to be undertaken at all known populations. The characterization should include documentation of all associated species, calculations of dominance, density, frequency, constancy, species diversity, and age class structure. This information is critical to understanding management needs and determining suitable areas for future reintroduction efforts.

213. Study community dynamics/ecology. Nothing is known about the habitat factors and dynamic processes that may be critical to the preservation of this species. Studies are needed to determine this species' response to seasonal and cyclic processes, periodic freezing, periodic flooding, interactions between species in the communities in which it occurs, differing management practices and disturbances, and growth in various seral stages. This information is critical in formulating management plans that will truly maintain and restore this species. Successful reintroduction of the species will be dependent on placing Walker's manioc within the appropriate ecological structure that will enable the species to become established.

2131. Study response to past land use practices. Since many members of the genus Manihot are opportunistic and colonize open areas, studying this species' response to various management actions such as canopy opening versus closure, grazing of surrounding vegetation, and creation of edge habitats through brush clearing or selective clearing is important in determining acceptable land management practices for

Walker's manioc habitat. Comparative observations of the past land uses of the known populations would provide insight on the effects of various disturbances. This information on the Mexico population would help in determining if the present land use of ranching is partly responsible for the decline in the population, is compatible or even helpful in maintaining the population.

2132. Study response to fire. The known populations do not have an age class distribution indicating successful replacement of senescent individuals. It is not known whether or not fire is an essential factor in creating habitat for juveniles and/or aiding seed germination. Studying the species response to fire could provide valuable management information for use in restoration, maintenance, and reintroduction. Fire may or may not prove to be an important factor in the ecology of the species.

2133. Study interactions with other species (beneficial and negative). The interactions between Walker's manioc and other species (plant and animal) need study. Observations at the U.S. site indicate that rodents gather dispersed or planted seed. This may be a contributing factor to a failure in seedling recruitment and establishment at this site; however, it could be important in seed dispersal for the species. Although insect predation has not been observed, the habitat surrounding the U.S. plant is infested with

large colonies of leaf-cutter ants. The invasive, non-native buffelgrass (*Cenchrus ciliaris*) is also abundant in the habitat surrounding this plant. The possibility of nurse plant interaction or beneficial interactions with other species is not known. The information provided by studies on interactions between Walker's manioc and other species would be useful in management plans and restoration efforts.

2134. Study the species' response to periodic freezing temperatures. Nothing is known about how periodic episodes of freezing temperatures affect this species. No studies have been carried out to determine what role, if any, freezes have on limiting distribution of Walker's manioc. It is known that plants in cultivation at UT-Austin were destroyed by a freeze; however, the duration, actual temperature, seasonal timing and other possible factors that were involved are unknown. The effect that freezing temperatures may have on limiting distribution and seedling recruitment and establishment needs study.

22. Study population biology. Nothing is known about the status of the three populations in terms of stability, demographic and genetic viability, phenology (relationship of climate and seasonality to plant life cycle stages), and reproductive biology. The degree of variation within the Mexico population and between the U.S. and Mexico populations is not known. This information is critical for management plans and reintroduction efforts.

221. Do a demographic analysis of populations that are large enough to show some demographic structure. An evaluation of the demographics of the Mexico population is needed. The U.S. site contains only one individual. Nothing is known about natural population variation and its effect on the age class distribution, survivorship curve, spatial relationships to other species, spatial patterning, and resource allocation patterns. This information would be useful in evaluating threats and areas of vulnerability as well as in developing management and reintroduction plans.
222. Characterize phenology and assess most vulnerable stages of the life cycle. Seasonal phenology for the species has not been determined. The two sites need periodic phenological observations throughout both the growing and dormant seasons to assess the species' response to a variety of climatic conditions. Local climatic data for each population also needs to be obtained at each observation time. This information would enable an assessment of the more vulnerable stages of the life cycle. Once critical life cycle stages are determined, management strategies could be devised to address the vulnerable stages and allow for higher recruitment within the populations.
223. Determine the primary means of reproduction in the wild. It is known the species reproduces both sexually and asexually (through tubercle buds). Studies need to be undertaken to determine the primary means of reproduction in the wild. San Antonio Botanical Garden has had success with vegetative propagation of the material obtained from

the UT-Austin specimens; however, only one seed-grown plant has been established from their collection. They have not yet successfully germinated seed from the extant U.S. plant (Patty Leslie, pers. comm. 1992). Determination as to whether or not the species reproduces primarily asexually, sexually, or both will be critical information for management and reintroduction success.

224. Study pollination biology and determine pollination requirements. Little is known of the pollination biology of Walker's manioc. No specific pollinators have been observed for the species. A detailed study including insect visitation, pollen predation, pollen viability, potential maximum population density needed for adequate pollen flow, and other aspects of pollination biology is needed in order to determine if pollination factors are limiting the species' reproduction. Once pollination requirements are determined, they must be incorporated into the management plans for the populations. The landowners of the U.S. site have observed that the flowers of that individual plant abort during hot, dry weather (pers. comm. 1992). The effects of seasonality and climate on pollination also need investigation. Another factor in pollination needing study is the potential effect of pesticides on the species' pollinators. This could be critical for the species as it presently is restricted to areas surrounded by cultivated fields and rangelands.

225. Study seed production and dispersal. Walker's manioc disperses seed from explosively dehiscent capsules. The seed viability rate, factors affecting seed production and viability, variation in seed

production between populations and seasons, and germination requirements are not known. The distance of seed dispersal in the field is not known. The role in which animals such as rodents, birds or ants may aid or obstruct seed dispersal is not known. This information is critical, as recent seed germination attempts from seed gathered at the extant U.S. site have not been successful. Reintroduction is dependent on the availability of genetically variable individuals grown from seed.

226. Study seedling recruitment. No seedlings have been observed at any of the sites. The reasons for this are unknown and need investigation. Optimum conditions for seedling growth need to be determined. A detailed study is needed to determine effects of disease and predation on seed production, habitat factors presently limiting seed production or seedling growth that could be managed, effects of freezing temperatures, and possible phenological requirements for seedling recruitment.
23. Study cultivation requirements. Cultivation studies are needed for the establishment of reintroduced populations and maintenance of cultivated populations. San Antonio Botanical Garden has only one seed-grown plant in cultivation. This was produced by a clone originally from the La Joya, Texas collection. Better knowledge of cultivation requirements is mandatory if a reintroduction program is to be implemented.

Walker's manioc is known to produce adventitious shoots from the tuberous roots. Cuttings root easily if first treated with a commercial rooting powder and then grown

under mist conditions (University of Texas at Austin Rare Plant Study Center, in litt. 1976).

Walker's manioc has also been grown from scarified seed. Seed was germinated on moist paper toweling in covered dishes incubated at 80 degrees Fahrenheit. This particular method achieved a germination rate of 18 percent (University of Texas at Austin Rare Plant Study Center, in litt. 1976). The reasons for this low germination rate are unknown, but could include poor fertilization as a result of a lack of cross-pollination.

3. Search for new populations. Once a more detailed profile of the habitat and community associations of this species is determined, areas of potential habitat should be surveyed for Walker's manioc. Although some areas have been surveyed for the species, there are still many areas of native vegetation that have not been surveyed due to lack of access on private lands. Many federal and state agencies have field personnel who could be helpful in searching for new populations of Walker's manioc. All such personnel should be educated about the appearance and extreme rarity of Walker's manioc, so that they might recognize new populations and encourage landowner support of recovery of the species. ..

4. Establish a botanical garden population and seed bank. Individuals from a collection near La Joya, Texas are maintained through the Center for Plant Conservation at the San Antonio Botanical Garden. Plants from the other populations should be maintained separately at San Antonio Botanical Garden, Lower Rio Grande Valley National Wildlife Refuge, and other institutions so that representatives from all populations can be maintained. Dr. Francisco Gonzalez Medrano plans to establish a cultivated collection of the two Mexico populations at a botanical garden in Mexico (pers.

comm. 1992). A seed bank has not been established for this species. At least two botanical garden collections and seed bank reserves would provide assurance against extinction if a loss of all natural populations should occur. Plants maintained in cultivation could also be used for research and as a source for use in reintroduction. Individuals from different populations should be maintained separately unless their genetic identities are determined to be identical.

5. Conduct a reintroduction program on the Lower Rio Grande Valley National Wildlife Refuge (LRGVR) and any State or private lands with suitable habitat volunteered for use. Due to the extreme rarity of Walker's manioc and the paucity of remaining protected natural habitat in the Lower Rio Grande Valley, a reintroduction of the species is necessary to aid recovery. The Service defines reintroduction as placing species in the general range where they occurred historically. Collection data available for this species is not precise, thus reintroduction will be undertaken in areas of suitable habitat within the historic range of the species.

51. Appoint a coordinating team to help plan and oversee the reintroduction program. A coordinating team for this species needs to be appointed by the Corpus Christi Ecological Services Field Office. The team should be assembled from interested members of the existing Texas Plant Recovery Team, knowledgeable members of other Federal and state agencies, and academia with interest and experience in conservation biology. The landowners of the U.S. site could also form part of the team. Botanists or agency members from Mexico should be on the team. Recovery of the species will be more successful under a coordinated U.S.-Mexico effort. The team should provide technical review to help plan the long-term management and reintroduction of this species. The appointment of a

coordinating team to help plan and oversee the reintroduction program would provide this recovery effort with a variety of knowledge and experience to better assess management strategies.

52. Incorporate the plan for the reintroduction program into applicable agency land management plans. The LRGVNR presently has an ongoing habitat restoration project and a land protection plan. The reintroduction program for Walker's manioc must be incorporated into future management plans to assure long-term success of the reintroduction program. Texas Parks and Wildlife Department (TPWD) lands volunteered for use in reintroduction should incorporate the program into their management plans to assure consistency and continuity of reintroduction efforts.
  
53. Propagate plants for reintroduction. Once a basic stock of plant material from the three populations (including the La Joya, Texas collection at San Antonio Botanical Gardens, the extant Hidalgo County, Texas site and the Tamaulipas, Mexico population) is established, seedlings should be cultivated for reintroduction. U.S. facilities exist at LRGVNR and San Antonio Botanical Gardens. Preferably, two cultivated collections should be maintained. Existing genetic integrity should be maintained by keeping individuals from different populations separate until population variation can be determined as non-detrimental and acceptable for the reintroduction program. The basic stock should be the result of sexual reproduction (i.e. from seed) so that reintroduced populations will be comprised of genetically variable individuals rather than clones. Vegetative propagation to increase numbers within initial basic stock is acceptable; however, these individuals should be tagged

and documented as clones of initial individuals and maintained separately within their respective populations. Propagation efforts and targets should be governed by a specific written management plan.

54. Do experimental plantings of seeds and various aged individuals at a selected natural site as a pilot project.

An appropriate natural site on a protected LRGVNR tract can be selected once more information on habitat requirements, community structure and community dynamics/ecology is known. Another small selected site could be placed on a TPWD tract to test for a different potential habitat profile. Once the site has been selected, experimental plantings (plantings done by hand due to the small size of the project) of seeds and various aged individuals should be done as a pilot project to provide information for future reintroduction efforts. The coordinating team for the species must review and approve the pilot project to evaluate readiness to attempt reintroduction, revise management strategies if needed, and to determine preliminary criteria for assessing present and future reintroduction sites. Careful records must be kept for the pilot project so that information gleaned from the experimental plantings can be used in the reintroduction program and in the management plans for the known sites. Number and source of seeds and individuals, maximum plant densities and their impact on reproductive success, soil preparations, weather conditions, insect predation, disease, animal interactions, nearby species and general community profile, and percentage successful establishment should be recorded. Additionally, records should be kept on parentage, seed treatments, germination rates, documentation of mortality occurrences and causes, human assistance in establishment (watering, weeding, etc.) and the time for the plant to reach reproductive

maturity. The pilot program could provide useful information on reproductive biology, species interactions, and population biology for the species. The pilot program could also provide information on management strategies to ensure establishment of functioning, reproducing populations. The pilot program will be considered a success when it has provided the necessary information for implementation and evaluation of reintroduction efforts. It may be that successive trials will prove necessary to achieve this success. If so, the successive trials could be monitored and evaluated over a period of three to five years.

55. Based on the results of Tasks 53. and 54., establish at least twelve reintroduced populations on refuge, State or private lands. Once the tasks of propagation for reintroduction and the pilot program have been successfully implemented, at least twelve reintroduced populations need to be established on suitable sites. This number is the present estimate of the number of populations needed to meet the goals of this recovery plan. The sites chosen should be in suitable existing communities with appropriate soils, pollinators and associated species based on information obtained from studies noted in Task 2. The sites chosen for reintroduced populations should be located within areas not immediately surrounded by agricultural use to prevent chemical drift and therefore, eliminate potential concerns that the agricultural community could have regarding the reintroduced populations. The coordinating team should provide oversight of the reintroduction program. The components chosen for the reintroduction program should provide some initial age class variation (i.e. seeds, seedlings, juveniles, and mature reproducing plants), if determined as natural in the wild population, to enable

the population to function more naturally from the beginning. The reintroduction should be planned so that the goal of self-sustaining populations of at least 100 reproductive individuals, each with an age class structure that demonstrates the plants are reproducing, becoming established, and functioning as an actual genetically variable population, can be achieved. The goal of reintroduction is to restore this species as a functioning component within its system; therefore, the community dynamics and ecology of the sites chosen are critical.

56. Develop a longterm monitoring program to assess reintroduction success. A monitoring program needs to be developed with the assistance of the coordinating team to assess reintroduction success. Reintroduction efforts may reveal a need for further information, revisions in management strategies, or revisions in the reintroduction program. The monitoring procedures used as part of the management plans for the natural populations should be implemented for the reintroduced populations to ensure valid comparisons.
  
6. Develop a public information and awareness program. Public education is a vital part of the recovery process; therefore, public awareness and cooperation is essential for the success of any recovery program. An informative program about Walker's manioc, its recovery plan, and the Endangered Species Act should be developed for presentation to private landowners and other interested groups. The program should describe tasks that the individuals or groups being addressed can accomplish to participate in recovery of the species.
  
7. Once downlisting is achieved, develop delisting criteria and a post-recovery monitoring plan. Once the objectives of this recovery plan are met, consideration of criteria needed to

delist the species and a plan for post-recovery monitoring of populations are needed. The post-recovery monitoring plan must be implemented for at least five years as required by the Endangered Species Act. All information needs for the species must have been met to accurately assess the criteria needed for delisting. If at any time the downlisting criteria are no longer being maintained, the species should be returned to the status of endangered.

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### III - IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines actions and costs for the Walker's manioc recovery program. It is a guide for meeting the objectives elaborated in Part II of this plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs. These actions, when accomplished, should bring about the recovery of Walker's manioc and protect its habitat. It should be noted that the estimated monetary needs for all parties involved in recovery are identified for the first three years only, and therefore are not reflective of total recovery costs. The costs estimated are intended to assist in planning. This recovery plan does not obligate any involved agency to expend the estimated funds. Though work with private landowners is called for in the recovery plan, private landowners are also not obligated to expend any funds.

#### Task Priorities

- Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
- Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.
- Priority 3 - All other actions necessary to meet the recovery objectives.

#### Abbreviations Used

- CPC - Center for Plant Conservation or other appropriate institution
- FWS - USDI Fish and Wildlife Service
  - ES - Ecological Services
  - LE - Law Enforcement
  - LRGVNR - Lower Rio Grande Valley National Wildlife Refuge
- PVT - Private Landowners
- TNC - The Nature Conservancy
- TPWD - Texas Parks and Wildlife Department
- UAT - Universidad Autónoma de Tamaulipas
- UNAM - Universidad Nacional Autónoma de Mexico

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$000)			COMMENTS
				FWS		Other	YEAR 1	YEAR 2	YEAR 3	
				Region	Program					
1	111	Inform and educate landowners	1	2	ES					
1	112	Encourage the establishment of stewardship agreements	5			TNC or TLSS	10.0	5.0	5.0	Year 4 and 5 two thousand
1	121	Determine landowner short-term and long-term land use goals	3	2	ES	UNAM/UAT or other and/or TNC	2.0 2.0	2.0 2.0	2.0 2.0	
1	122	Develop and implement management plans for known sites	5	2	ES		10.0	5.0	5.0	Year 4 and 5 also five thousand
1	123	Develop a monitoring program with landowner association	5	2	ES	UNAM/UAT or other (through ES) PVT	5.0 -0-	5.0 -0-	5.0 -0-	Year 4 and 5 also total five thousand
1	211	Study soils and underlying geology	3	2	ES	UNAM/UAT or other (through ES)	1.0 -0-	0.5 -0-	0.5 -0-	Priority 1 because this information is not known

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$000)			COMMENTS
				FWS		Other	YEAR 1	YEAR 2	YEAR 3	
				Region	Program					
3	55	Establishment of reintroduced populations on suitable site	5	2	ES LRGVNR	TPWD, TNC or other	3.5 8.0 3.5	3.5 8.0 3.5	2.0 4.0 2.0	Year 4 and 5 also total eight thousand
2	56	Monitor reintroduced populations	5	2	ES LRGVNR	TPWD, TNC or other	3.0 2.0	3.0 2.0	3.0 2.0	Year 4 and 5 also total six thousand
3	6	Develop a public information and awareness program	3	2	ES	TPWD	1.5 .5	1.0 .5	1.0 .5	
<b>Total</b>			:				<b>167.5</b>	<b>144.5</b>	<b>127.5</b>	

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$000)			COMMENTS
				FWS		Other	YEAR 1	YEAR 2	YEAR 3	
				Region	Program					
1	212	Determine community structure	3	2	ES	UNAM/UAT or other (through ES)	10.0 -0-	3.0 -0-	3.0 -0-	Priority 1 because this information is not known
1	2131	Study response to past land use practices	3	2	ES	"	10.0 -0-	10.0 -0-	5.0 -0-	"
1	2132	Study response to fire	3	2	ES	"	5.0 -0-	5.0 -0-	5.0 -0-	"
1	2133	Study interactions with other species	3	2	ES	"	5.0 -0-	5.0 -0-	5.0 -0-	"
1	2134	Study response to periodic freezing temperatures	3	2	ES	"	5.0 -0-	5.0 -0-	5.0 -0-	"
1	221	Do a demographic analysis of populations with demographic structure.	3	2	ES	"	10.0 -0-	10.0 -0-	5.0 -0-	"
1	222	Characterize phenology	3	2	ES	"	5.0 -0-	5.0 -0-	2.0 -0-	"

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$000)			COMMENTS
				FWS		Other	YEAR 1	YEAR 2	YEAR 3	
				Region	Program					
1	223	Determine the primary means of reproduction in the wild	3	2	ES	UNAM/UAT or other (through ES)	5.0 -0-	5.0 -0-	5.0 -0-	Priority 1 because this information is not known
1	224	Study pollination biology and determine pollination requirements	3	2	ES	"	5.0 -0-	5.0 -0-	5.0 -0-	"
1	225	Study seed production and dispersal	3	2	ES	"	5.0 -0-	5.0 -0-	5.0 -0-	"
1	226	Study seedling recruitment	3	2	ES	"	7.0 -0-	5.0 -0-	5.0 -0-	"
1	23	Study cultivation requirements	3	2	ES	CPC or other	2.5 2.5	2.5 2.5	2.5 2.5	"
1	13	Enforce applicable laws and regulations	on-going	2	ES LE	TPWD	1.25 .25 .5	1.25 .25 .5	1.25 .25 .5	

RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURA- TION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES (\$000)			COMMENTS
				FWS		Other	YEAR 1	YEAR 2	YEAR 3	
				Region	Program					
1	3	Search for new populations	on-going	2	ES	TPWD UNAM/UAT or other (through ES)	5.0 1.0 -0-	5.0 1.0 -0-	5.0 1.0 -0-	Year 4 and 5 also six thousand
1	4	Establish a botanical garden population	5	2	ES	CPC	1.0 2.0	1.0 2.0	1.0 2.0	Year 4 and 5 also total three thousand
2	51	Appoint a working team to help plan and oversee the reintroduction program	5	2	ES		4.0	4.0	4.0	Year 4 and 5 also four thousand
2	53	Propagate plants at greenhouse facilities	5	2	ES LRGVNR	CPC or other	3.0 5.0	3.0 5.0	3.0 5.0	Year 4 and 5 also total eight thousand
2	54	Experimental pilot project at suitable site	3	2	ES LRGVNR	TPWD, TNC or other	5.0 5.0 2.5	5.0 5.0 2.5	5.0 5.0 2.5	

## Appendix

### Principal Comments Received On The Walker's Manioc Technical/Agency Draft Recovery Plan

This recovery plan was sent out as a technical/agency draft in June of 1993. The Service initially distributed 56 copies of the draft plan to agencies, members of the Texas Plant Recovery Team, individuals and county judges. The Service sent out 18 letters notifying local and national organizations of the plan's availability for public review and comment. The Service also distributed 13 copies of the draft plan to agencies, organizations and individuals who requested a copy. Comments were received from the 18 individuals, agencies and organizations listed below:

Ms. Joyce Obst, Texas Agri-Women, Rio Grande Valley Chapter  
Mr. Joe Ideker, Native Plant Project  
Mr. Gary Valentine and Mr. Mike Black, Soil Conservation Service  
Dr. Hugh D. Wilson, Texas A&M University..  
Dr. David J. Rogers  
Mr. Lee Elliott, Texas Parks and Wildlife Department  
Mr. Conrad G. Keyes, Jr., United States Section,  
International Boundary and Water Commission, United States  
and Mexico  
Dr. Francisco Gonzalez Medrano, Universidad Nacional  
Autonoma de Mexico  
Mr. Joe B. Metz and Ms. Sharon Rees Waite  
Mr. Efren Garza, Mayor, City of Penitas, Texas  
Ms. Gena K. Janssen, Texas Parks and Wildlife Department  
Ms. Jackie M. Poole, Texas Parks and Wildlife Department

Dr. David Riskind, Texas Parks and Wildlife Department  
Mr. Matthew W. Wagner, Texas Parks and Wildlife Department

Although many comments were received after the August 13, 1993, deadline, the Service was able to incorporate all comments into the plan and the following response section. All comments were considered when revising the draft plan. The Service appreciates the time that each of the commentors took to review the draft and to submit their comments.

The comments discussed below represent a composite of those comments received. Comments of a similar nature are grouped together. Substantive comments that question approach, methodology, or financial needs called for in the draft plan, or suggest changes to the plan are discussed here. Comments received that related to the original listing decision and general comments about the Endangered Species Act that did not relate to Walker's manioc are not discussed here. Comments that offered further clarification of detail and specificity in biological studies and simple editorial suggestions such as better wording, spelling or punctuation were incorporated as appropriate without discussion here. Favorable, supportive comments were also received, but are not summarized here.

All comments received are retained as a part of the Administrative Record of recovery plan development in the Corpus Christi, Texas, Ecological Services Field Office.

Comment: We can support the plan only under reasonable conditions that consider private property rights and just compensation for private property since USFWS is imposing restrictions on private lands.

Service Response: The Service believes the recovery plan to be reasonable in that actions are stepwise and practical. Landowners are not presently legally required to conserve or manage endangered plants on their property. However, if landowners receive Federal funds or authorization for a project on their land, the Federal action agency must ensure that those activities do not jeopardize the continued existence of the species.

Comment: The recovery plan should not impose costly regulations on private citizens, city and county officials or endanger the lives of humans by restricting the operation of the International Boundary and Water Commission's Lower Rio Grande Flood Control Project.

Service Response: The recovery effort for Walker's manioc will not result in further regulations on local governments, nor will reintroduction take place within the floodway system. At present, the legal responsibilities of landowners with endangered plants on their property are few. Please note the response above. Section 7 consultation with the Service regarding endangered plants on private lands is only undertaken when Federal monies or authorization are associated with proposed projects. The plan includes a discussion of the Section 7 process. The recovery plan does not designate recovery tasks to agencies which could not be expected to have those responsibilities in recovery of the species. The development of a recovery plan is not a rulemaking procedure and thus, does not impose further regulations.

Comment: Any reintroduction must not interfere with flood control and boundary stabilization activities by the United States Section, International Boundary and Water Commission, United States and Mexico, (USIBWC).

Service Response: Sites within the maintained USIBWC floodway will not be selected for reintroduction. The Service intends to coordinate reintroduction efforts so that they do not conflict with the USIBWC Lower Rio Grande Flood Control Project.

Comment: Possibly a joint monitoring program with the USIBWC could be worked out to assess reintroduction of the species on or near the Lower Rio Grande Flood Control Project.

Service Response: The Service would appreciate a coordinated effort with the USIBWC on monitoring reintroduced populations established near the Lower Rio Grande Flood Control Project.

Comment: The Service needs to understand that Mexico's priorities may not be the same as theirs in the protection of the species' populations.

Service Response: While the Service understands that Mexico is a sovereign nation and may have priorities regarding species conservation that could differ from ours, we believe that Mexico is also interested in protecting and increasing knowledge of rare species.

Comment: The source of funding should be clearly stated in the recovery plan with an explanation of recovery plan costs placed within the narrative portion of the plan.

Service Response: Costs for recovery plan tasks are not itemized and explained in the recovery plan narrative because they are estimates based on costs for similar studies and not, generally, ongoing contracts. Funds for recovery plan tasks are appropriated for those tasks in the form of funded proposals, fund transfers through Section 6 cooperative agreements with the State, and through private lands programs. Proposals for studies using these monies are compared with other proposed studies for priority on Service state and regional levels.

Comment: Does the Service anticipate determination of the plant's habitat requirements to be made by 1996 as the plan would seem to indicate?

Service Response: The Service has noted 1996 as a goal; however, if the necessary studies are not funded or are delayed, the Service will not have a better determination of this species' habitat at that time.

Comment: Does the responsibility to search for additional populations in Mexico belong to Dr. Medrano as described in the Conservation Planning and Management section?..

Service Response: Dr. Medrano is surveying for rare plant species in Tamaulipas as part of a cooperative agreement study. The responsibility for searching for additional populations does not belong to any one individual.

Comment: The format of the Implementation Schedule is awkward and difficult to follow when comparing recovery costs and the format of the numbering system within the text does not allow for easy reference.

Service Response: The Service has tried to develop a format for Implementation Schedules that coordinates recovery tasks, responsible agencies and costs in as organized a manner as possible given the detail required for the schedules. The format of the numbering system in the text is standardized as such to enable easier referencing than with a Roman numeral/alphabet combination as sometimes used in narrative outline reports.

Comment: The inclusion of photographs into recovery plans would be helpful to agencies and individuals tasked with protection of this species.

Service Response: While the inclusion of photographs may prove helpful, it would be prohibitively expensive. Agencies and individuals may contact the Service to obtain photographs of the species.

Comment: A section should be added to the Executive Summary describing the significance of the species and what impacts might be if it was not protected from extinction.

Service Response: In order that the Executive Summary be concise, the Service has not included reasons justifying significance. The species' status as listed endangered denotes its significance and imperilment.

Comment: We assume soil and geologic studies will also provide information on erosion characteristics.

Service Response: This information would be included in a general soils study.

Comment: Basic recovery efforts should focus on habitat restoration, not protection of plant populations.

Service Response: While the Service understands and supports the need for habitat restoration, the habitat for Walker's manioc is as yet undetermined. The Service believes that protection of existing plant populations is critical for survival of the species.

Comment: Initial recovery dollars should be directed towards defining the ecology of existing populations and searching for additional populations in the United States. Following work on wild populations, more monies could then be directed towards reintroduction techniques and procedures.

Service Response: The Service agrees, and has stressed the need for gathering information to enable us to better understand the ecology of the extant populations in the plan. However, cultivation techniques to enable reintroduction need early development as the process will be dependent on having a basic stock of genetic individuals which will take a fairly long time to obtain. Monies are presently being spent on studies that involve surveys for additional populations and gaining information about the function of the species in the Mexico population.

Comment: Summation discrepancies in the Executive Summary were noted for the entry containing the years 2003-2008.

Service Response: We have noted those discrepancies and revised the plan accordingly.

Comment: What is to prevent oil and gas production on sites chosen for reintroduction?

Service Response: Plants receive full protection under the Endangered Species Act when they occur on Federal lands. The Section 7 consultation process discussed within the plan addresses the means by which species are protected from impacts which jeopardize their continued existence.

Comment: Was Ringgold Barracks the actual locality for Schott's collection or was he stationed there and reported all of his specimens from that location?

Service Response: The Service does not know with certainty whether Schott's collection was actually from an unspecified location in Ringgold Barracks or collected elsewhere in the surrounding area. We can only rely on the information present on the herbarium specimen.

Comment: Are there notes surviving indicating precisely where Walker collected her specimens?

Service Response: The information presented in the plan is all the Service has regarding previous collections of the species. We are not aware of any notes surviving that would indicate better detailed information.

Comment: The Lower Rio Grande Valley National Wildlife Refuge (LRGVNWR) has a high turnover rate for staff that could be detrimental to the reintroduction program.

Service Response: The LRGVNWR is supportive of the reintroduction program and will incorporate the program into their existing Land Protection Plan and future Refuge management plan. The Service believes that this ensures a continuity in the program that will diminish any impact that inevitable staff turnover could have.

Comment: The emphasis of the plan on establishing reintroduction sites only on LRGVNWR lands is too limiting and may even be inappropriate given the lack of knowledge about suitable habitat for the species. Sites for reintroduction should include Texas Parks and Wildlife Department Lands and other lands, including private, with suitable habitat.

Service Response: The Service agrees and has made the appropriate revisions in the recovery plan. We appreciate being given the opportunity to use non-Federal lands with suitable habitat.

Comment: All recovery efforts for this species should only involve Federal funds and use only Federal lands.

Service Response: While the Service initially considered only locating sites on Federal lands, several other commenters noted this as too limiting, especially given our present lack of knowledge as to the habitat requirements of the species. Please reference the comment noted above. Federal lands allow protection under Section 7. The Service plans to reintroduce Walker's manioc in areas of suitable habitat with its range on Federal, State, and even private lands volunteered for that specific use. It is expected that Federal monies and monies made available to the State will be the primary funding for the reintroduction effort.

Comment: The term reintroduction refers to the establishment of a species at a site where it occurred before but was later extirpated. What the plan is actually proposing to implement is an introduction.

Service Response: The Service defines reintroduction as the restoration of a species into appropriate habitat within its historical range. That definition includes the actions to be implemented by this plan. The original collection data for Walker's manioc were not detailed enough to enable the Service to determine a specific location as the precise occurrence. We believe that by establishing the species in the same general area within which it once occurred, we are within our definition of reintroduction.

Comment: It must be considered that periodic freezes encountered in this area could have been the driving force that reduced the Texas populations.

Service Response: This has not been studied; however, we have added a study of the effects of periodic freezing temperatures within the plan. The Service does not believe that periodic freezes have been the driving force in the endangerment of this species. Destruction of native habitat has likely been the largest threat to this species.

Comment: Normally, plants with a large tuberous root are not susceptible to incidental contact with herbicides selective on broad-leaved plants. Hormonal chemicals may reduce the leaves, but seldom have a lasting effect.

Service Response: Herbicide susceptibility has not been studied for Walker's manioc. With so few plants remaining, the Service believes it is an unacceptable risk to assume an effect may only be temporarily harmful as opposed to acting systemically.

Comment: Mechanical and chemical destruction of habitat occurred in the past and are now secondary threats. The primary threats now are those of plant collectors and urban expanse.

Service Response: Habitat conversion to agricultural and urban development is occurring and poses a real threat to the little remaining native habitat left in the Lower Rio Grande Valley. These activities are still leading to further habitat destruction, modification and fragmentation. Plant collectors do pose a threat to some species; however, the Service does not have documentation where collection has been a threat to Walker's manioc.

Comment: Given that this is one of the few U.S. endangered species with a direct link to a food plant that is important to the human global economy, the recovery priority number should be higher.

Service Response: A recovery priority number of 5 was assigned for this species at the time of its being listed as endangered. This number designation was arrived at by considering the degree of threat, the taxonomic level and the degree of recovery potential. Walker's manioc was designated as species level with a high degree of threat; however, the recovery potential was assessed as being low. The low recovery potential designation results from the low number of individuals in the wild. The Service can reassess the recovery priority number designation in the future if recovery potential appears to increase.

Comment: Additionally, given its importance noted above, maximal media exposure to recovery operations could provide a plant conservation perspective that can be appreciated by the public.

Service Response: The public is aware of the development of the recovery plan for Walker's manioc. The plant and its recovery plan have been the subject of several local agriculture newsletters and a segment on television. The Service would like to see this recovery operation receive attention that could give the public an appreciation of plant conservation efforts.

Comment: Referring to the University of Texas at Austin as UTA is misleading. The abbreviation should be UT-Austin; UTA is an abbreviation for University of Texas at Arlington.

Service Response: We have changed the abbreviation as suggested within the plan.

Comment: The priority task number for Task 3, Search for new populations, should be noted as one (1) rather than two (2) due to the low number of known populations.

Service Response: We agree and have noted the change in the Implementation Schedule.

Comment: The priority task number for Task 4, Establish a botanical garden population, should be noted as one (1) rather than two (2) due to the low number of known individuals in the wild and in cultivation presently.

Service Response: We agree and have noted the change in the Implementation Schedule.

Comment: One commenter provided numerous notes in the margins of a marked up copy that requested Service clarification of text in the form of requests for greater detail or specificity.

Service Response: These comments have been incorporated into the plan or have been included in modifications within the plan in revision. Comments that called for substantive changes in the plan or requested additions to the plan have been incorporated into the comment section.

Comment: Natural population initiation may be associated with the development of openings in existing canopy or the scarification of soils, in which case the age structure may naturally be even without apparent evidence of reproduction.

Service Response: The Service has modified portions of the plan that covered age class structure to allow for this possibility by stressing a need for the structure to reflect that which exists in the wild.

Comment: The study of the ecology of the species should include the species' response to flooding of the known sites, surrounding habitat, and potential reintroduction sites.

Service Response: We have added that factor as one within Task 213.

Comment: The requirements of this recovery plan restrict the development of infrastructure improvements in this economically distressed area.

Service Response: The Service does not believe the recovery plan restricts infrastructure improvements. Currently, all Federal agencies are required to comply with the Endangered Species Act. Additionally, funding for implementation of recovery plan tasks come from separate sources and would not reduce funds available for drainage, water or sewer projects.